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CONTENTS:

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THE DISTRIBUTION AND AFFINITIES OF THE VEGETATION OF THE ATHABASCA-GREAT SLAVE LAKE REGION[1]

HUGH M. RAUP

A STUDY of the flora of the Athabasca-Great Slave Lake region, in northwestern Canada, has revealed certain outstanding features of distribution and affinity. Although it is intended that a series of papers shall be prepared upon the more detailed investigations, the writer takes this opportunity to make a brief statement of the major problems involved. He wishes to express his appreciation of the valuable assistance received from Professor M. L. Fernald of Harvard University, especially in correlating the Mackenzie basin flora with that of northeastern North America. He is also much indebted to many persons in the Geological Survey at Ottawa and in the government organization at Fort Smith, North West Territories, who have helped to forward the field work.[2]

[1] Published by permission of the Director, National Museum of Canada.

[2] The writer and his wife have been engaged in botanical survey operations in the Athabasca-Great Slave Lake region during the past four summers. In 1928 and 1929 the trips were financed by the National Museum of Canada, the work being done under the general direction of Dr. M. O. Malte, Chief Botanist at the National Museum at Ottawa. In these two seasons a survey of the flora of the Wood Buffalo Park has been started. Thanks are due to the many disinterested persons who have assisted the field parties, especially to the officers of the Hudson's Bay Company, who have been unfailing in their efforts to facilitate outfitting and transportation. The party in 1926 included three students, Harold Stallsmith, Orville Myers, and E. J. Kunde, while that in 1927 included Miss Catherine Raup, and Mr. R. L. Fricke, a taxidermist from the Carnegie Museum, Pittsburgh, Pa., who made a collection of birds and small mammals. In the Wood Buffalo Park the wardens have served as guides and assistants. Mrs. Raup has looked after the most of cryptogamic collections, while the writer has collected the ferns and flowering plants.

The following is an outline of itineraries for the field seasons. (C) indicates that collections and studies of local distribution problems were made at the places where it appears in the list. Modes of conveyance are indicated by: (St)—steamer or motor tug, (Ca)—canoe, (H)—pack horse, (W)—wagon or buckboard, (P)—back packing.

A section of the vegetation reaching from the Slave River westward to Moose Lake, about 75 miles away, shows a variety of types, ranging from the flood plain sloughs of the lowlands to the prairies and thick timber on the higher ground. An examination of the distribution of these types soon suggests a strong correlation with the topographic features of the region, and leads to an investigation of the geologic and physiographic processes which have produced this topography. Botanizing and comparing notes and collections with similar situations in other regions, one is impressed with the openness of the plant associations, and with the comparatively small number of species involved in them. The plants that are there show affinities with floras of widely spearated regions, while many of the common species of the Canadian forests elsewhere are absent or very rare in the Athabasca-Great Slave Lake district.

Topographic History of the Athabasca-Great Slave Lake Region

Athabasca and Great Slave Lakes lie in the zone of surface contact between the pre-Cambrian rocks of the "Canadian Shield" to the

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In the four summers, approximately 4400 miles have been traveled within the region, i. e., north of Waterways, the end of steel.

1926: Left Waterways (Ca) June 30; Calumet, July 4–6 (C); mouth of Embarras channel, Athabasca delta, July 11 (C); Chipewyan, July 12–13; camp about 10 miles east of Chipewyan, north shore, Athabasca Lake, July 14 (C-lichens); Shelter Point, July 14–Aug. 4 (C); left Chipewyan Aug. 7 (St); Fitzgerald, July 8 (C); arrived Waterways, Aug. 12.

1927: Left Waterways June 1 (St); left Chipewyan (Ca) June 6; Quatre Fourches channel, Peace delta, June 7 and 9 (C); 30th base line, Slave River, June 10–20 (C); Ft. Smith, June 22–28 (C); Resolution, July 2–5; Keith Island, East arm of Great Slave Lake, July 7 (C); Taltheilei Narrows, July 8–11 (C); Fairchild Pt. and vicinity, July 12–Aug. 20 (C); Maufelly Pt., July 15 (C); Fort Reliance, Aug. 7 (C); left Fairchild Pt., (St) Aug. 20; Yellowknife Bay, Aug. 23 (C); Rae, Aug. 24; arrived Waterways, Sept. 1.

1928: Left Waterways (St) June 6 (C); left Ft. Smith, June 14 (W); Smith to Pine Lake, June 14–17 (C); Pine Lake and vicinity, June 17–July 12 (C); trip to Lane Lake (Ca), June 26 (C); Pine Lake to Peace Pt. (H), July 12–15 (C-Round Lake, July 14); Peace Pt., July 15–22 (C); Peace Pt. to slough country along upper Murdock Creek, July 22–26 (Ca); Murdock Creek, July 26–29 (C); Government Hay camp, Slave River, July 29–Aug. 16 (C); Hay camp to Fitzgerald via the prairies along Salt River (H), Aug. 16–22 (C-prairies, Aug. 19–20); arrived Waterways, Aug. 30.

1929: Left Waterways (St), June 5; left Ft. Smith (Ca), June 12; portage, Salt River village to Little Buffalo River (W), June 13; started up Little Buffalo (Ca), June 15; falls of Little Buffalo, June 18–24; passed winter trail to Sucker Creek July 2, and Nini-sheth Hills July 7–8; Moose Lake, July 12–17 (C); Moose Lake to Pine Lake (P), July 17–20; Pine Lake, July 20–Aug. 1 (C); Pine Lake to Moose Lake, Aug. 1–4 (H); Moose Lake, Aug. 4–19 (C); Moose Lake to Government Hay camp (H), Aug. 19–26; arrived Ft. Smith, Aug. 27, and Waterways, Sept. 4.

Fig. 1 is a map showing the localities mentioned in this paper.

eastward, and the later, Paleozoic rocks of the main part of the Mackenzie basin. Paleozoic limestones are exposed along the Slave

Fig. 1. Map of the Athabasca-Great Slave Lake Region

River about fifty miles below Athabasca Lake, along the lower Peace River, in the lower valley of the Athabasca River, and about the western arm of Great Slave Lake. Cretaceous strata overly the

Paleozoic rocks in the Clearwater River district on the Athabasca, about one hundred and fifty miles south of Athabasca Lake.

Lake Athabasca lies almost wholly within the pre-Cambrian rocks, as does the eastern arm of Great Slave Lake. The northern arm of the latter is on the contact, having its east shore of granites and gneisses, and its west shore of Paleozoic sediments. The broad, western arm of Great Slave Lake lies on Paleozoic rocks.

The Slave River follows the contact roughly, and the isolated granite hills along its upper course are western outliers of the pre-Cambrian mass. A western extension of the older rocks in the vicinity of Ft. Smith and Ft. Fitzgerald, about one hundred miles below Athabasca Lake, forms unnavigable rapids in the river, and is the only hindrance to navigation by steamer between Ft. McMurray and the Mackenzie delta. These granitic outliners, rising like islands out of the modern alluvial deposits, are also surrounded at their bases by Paleozoic sediments, indicating their probable, similar position relative to the seas which invaded the continent in those times.

The pre-Cambrian rocks consist largely of granites and gneisses, although there are isolated masses of highly altered, more ancient sediments and basic intrusives. South of Lake Athabasca there are extensive sandstone deposits which are referred to the pre-Cambrian, though they are not certainly correlated. These later sediments are very little disturbed.

The Cambrian, Devonian, and Silurian periods were marked by the invasion of the Mackenzie basin district by epi-continental seas, whose eastern shores followed, in general, the present contact line with the pre-Cambrian. The Cambrian is not exposed in the Athabasca-Great Slave Lake district, appearing only in the Mackenzie valley, farther northward.[1] Silurian and Devonian strata are the underlying rocks in the region under consideration, and are exposed at several places on the Athabasca, Peace, and Slave Rivers, about the western arm of Great Slave Lake, and in the region southwest of Ft. Smith.[2] The outcrops follow, in general, bands of country extending

[1] Williams, M. Y. *Reconnaissance Across Northeastern British Columbia and the Geology of the Northern Extension of the Franklin Mountains, N. W. T.* C. G. S. Summary Rept. (1922) Part B. 65–87.

[2] Camsell, Charles, and Malcolm, Wyatt. *The Mackenzie River Basin* (Revised Edition). Memoir 108, C. G. S., Geological Series No. 92 (1921). (This paper gives an admirable summary of the geology, topography, and natural history of the region so far as these were known at the time of its publication. It is also valuable for its extensive bibliography.)

in a northwest and southeast direction. They consist mainly of dolomitic limestones with an abundance of gypsum in the Silurian, and thick limestones and shales in the Devonian. Except in the Mackenzie and Franklin Mountain districts in the Mackenzie River region, the beds are very little disturbed.

Whether there are any deposits in the region between the Devonian and the Cretaceous is uncertain. No Carboniferous rocks are to be found except in the mountains west of the Mackenzie.[1] The vast deposits of the Cretaceous seas form a disconformable contact with the Devonian, but with a very slight angular unconformity, suggesting a wide-spread uplift between the Devonian and Cretaceous, and considerable erosion of the former.[2] The Cretaceous sea covered practically all of the present Mackenzie drainage basin, and its sediments are found folded into the mountains to the westward. Throughout most of the basin its beds of limestones, sandstones, and shales are nearly horizontal.

There is evidence that the thick Cretaceous deposits were entirely removed in some places prior to the Eocene.[3] They are entirely absent in the Athabasca-Great Slave Lake region, except in the plateaus of the southern and western section. They form great uplands on the upper Athabasca, Peace, Hay, Liard, and Peel Rivers, and are known or thought to form the outlying plateau areas represented by Birch Mountain, west of the lower Athabasca;[4] the Buffalo Head Hills, between the Peace and the Wabiskaw;[5] the Watt Mountains, between the Peace and upper Hay River;[6] the Caribou Mountains, between the lower Peace and Great Slave Lake;[6] the Eagle Mountains, west of Hay River;[7] and the Horn Mountain plateau, north of the Mackenzie River and west of Horn River.[8] The positions of these

[1] Hume, G. S. *Mackenzie River Area, District of Mackenzie, Northwest Territories.* C. G. S. Summary Rept. (1923) Part B. 11.

[2] Hume, G. S. Ibid. 11.

[3] Hume, G. S. Ibid. 12.

[4] Camsell, Charles, and Malcolm, Wyatt. Ibid. p. 68.

McConnell, R. G. *Report on a Portion of the District of Athabasca Comprising the Country between Peace River and Athabasca River North of Lesser Slave Lake.* C. G. S. Ann. Rept. v. Pt. 1, 43–44 D.

[5] McConnell, R. G. Ibid.

[6] Cameron, A. E. *Hay and Buffalo Rivers, Great Slave Lake and Adjacent Country.* C. G. S. Summary Rept. (1921), Part B. 29.

[7] Camsell, Charles, and Malcolm, Wyatt. Ibid. 67.

Cameron, A. E., *Post-Glacial Lakes in the Mackenzie River Basin, Northwest Territories, Canada.* Journ. Geol. xxx. 341 (1922).

[8] Whittaker, E. J. *Mackenzie River District between Great Slave Lake and Simpson.* C. G. S. Summary Rept. (1921), Part B. 54.

outlying plateaus, all 2000 feet or more in height, are of considerable importance in the arrangement of post-Glacial topography, as will be shown later. Cretaceous uplands are also known on Great Bear Lake.

It is thought that the main lines of the Mackenzie drainage basin were formed in very early Tertiary or late Cretaceous time,[1] and have been able to maintain themselves not only throughout minor crustal movements in later times, but also through the period of mountain-building in the Mackenzie valley, and through most of the Pleistocene.[2] The dissection has gone far below the Cretaceous, and has cut through the Devonian and Silurian, reaching into the Cambrian.

It appears, then, that the major surface features of the Mackenzie basin are formed by the extensive erosion, along old and well-established drainage lines, of the nearly horizontal sedimentary deposits of the Cretaceous and Paleozoic seas. The only notable disturbance has been in the mountain-building activities in the Rockies to the westward and in the minor folding in the Mackenzie valley. Such must have been the conditions at the opening of the Pleistocene. The only Tertiary deposits are localized on the Pembina River, in the Fort Norman district, and about the headwaters of the Peel River. The last two are referred to the Eocene on fossil evidence.[3] The nature of the fossils indicates that there was a distinctly temperate climate at the time of their deposit.

The interaction of the Cordilleran and Keewatin ice sheets in the Athabasca-Great Slave Lake region is not known. The surface materials show only the result of the Keewatin, whose ice front entered the region from the east and northeast.[4] It has been generally accepted that the ice completely covered all the uplands, although this is supported by few critical observations. From a study of moraines, elevated shore lines, and post-Glacial lake deposits, A. E. Cameron had outlined the order of events in the recession of the last ice sheet from the region. The writer's observations on the topog-

[1] Hume, G. S. Ibid. 12–13.

[2] Cameron, A. E. *Post-Glacial Lakes in the Mackenzie River Basin, Northwest Territories, Canada.* Journ. Geol. xxx. (1922).

[3] McConnell, R. G. *Report on an Exploration in the Yukon and Mackenzie Basins.* C. G. S. Ann. Rept. iv. 22–23 D. (1888–89).

[4] Tyrrell, J. B. assisted by Dowling, D. B. *Report on the Country between Athabasca Lake and Churchill River with Notes on Two Routes Traveled between the Churchill and Saskatchewan Rivers.* C. G. S. Ann. Rept. viii. Part D. (1896).
Cameron, A. E., Ibid.

raphy and plant cover have tended to bear out this outline. Cameron's work will be briefly summarized here.

The glacier, entering the basin by way of drainage lines which had probably been long established in the eroded pre-Cambrian plateau to the eastward, crossed the valley of the present Slave River and sent tongues into the Cretaceous uplands by way of the ancient valleys. Hence there were lobes up the Athabasca, Wabiskaw, Peace, and Hay and Buffalo Rivers, and a lobe into the upper Mackenzie valley. It appears that these lobes were effectually kept apart by the uplands of the Buffalo Head Hills, and Birch, Watt, Caribou, and Eagle Mountains. The waters of the main streams were impounded against the ice front, forming glacial lakes, whose outlets were probably toward Hudson Bay, since the normal route to the Mackenzie valley was probably blocked by ice. The lobes apparently did not recede at a uniform rate, so that a series of lakes was formed in the river valleys and in the newly deepened depressions of Athabasca and Great Slave Lakes.[1] While the ice covered the main part of the area, and extended far up the river valleys, a lake occupied the upper Hay River district, west of the Caribou plateau, and extended southward and eastward in the valleys of the Peace, Wabiskaw, and Athabasca. The plain of the bottom of this lake is found at about the 1600-foot contour line. (See Fig. 2). The next lake stage was formed when the ice had retreated many miles to the eastward. Less well-defined lobes still covered the head of the Mackenzie, the lower reaches of the Hay, and the eastern half of the present Athabasca Lake. A great lobe still occupied most of the upper Slave River valley. The Caribou mountains formed a peninsula in this lake, separating large bays which lay in the valleys of the Hay and Peace Rivers. A third bay extended up the Athabasca 100 miles or more. Drainage was probably still accomplished by valleys to the southeastward. The plain of this lake bottom may be identified, approximately, with the 1100-foot contour line (see Fig. 3).

A third lake expansion occurred when the ice covered only the eastern part of Great Slave Lake. It is probable that the Mackenzie was opened at about this time, and that the eastern drainage was discontinued. There were two main basins, one in the Athabasca

[1] On the origin of the Athabasca and Great Slave Lake basins see:
Cameron, A. E. Ibid.
Alcock, F. J. *The Origin of Lake Athabasca.* Geographical Rev. x. 44 (1920).
Tyrrell, J. B. assisted by Dowling, D. B. Ibid.

River and Lake—lower Peace area, and the other in the Great Slave Lake area. The latter had its southwestern shore line extending from the head of the Mackenzie southeastward to an area south of Buffalo Lake, and thence eastward. West of the Slave River the shore lay

Fig. 2–5. Post-Glacial lake expansions in the Athabasca-Great Slave Lake region when the water, impounded against the retreating front of the Keewatin ice sheet, stood at about the 1600-foot level (2), the 1100-foot level (3), the 800-foot level (4), and the 700-foot level (5). (Reproduced by permission of *A. E. Cameron.*)

approximately at the limestone escarpment which forms the northern margin of the Alberta Plateau, known locally as Salt Mountain.[1] East of Slave River the shore was at the margin of the pre-Cambrian shield. Thus the two basins were united, and stood at what is now about the 800-foot level (see Fig. 4).

[1] Camsell, Charles and Malcolm, Wyatt. Ibid. 17–18.

At the 700-foot level (see Fig. 5) the two basins were separated except for the connecting Slave River. Great Slave Lake was still much enlarged, having a long southern arm which extended to about the present position of Ft. Smith, on the Slave River. The Athabasca Lake basin still had a long extension westward up the Peace, with minor ones in the Athabasca and upper Slave River valleys. These lakes stood only a few feet above the present lake levels, the modern land and water relations having been acquired by further drainage, probably due to the tilting of the basins, and by the formation of wide alluvial deposits where the main streams enter the settling basins. The Peace and Athabasca have so filled the western extension of Athabasca Lake that the only remaining water is in the shallow Lake Claire and in the neighboring smaller lakes. Slave River meanders a total distance of about two hundred miles below Ft. Smith, through the silts with which it has filled the southern arm of Great Slave Lake.[1] With the formation of natural levees in these deposits, and the wandering of the streams, there have arisen extensive, ponded, abandoned channels.

Below the heights of the Cretaceous erosion plateaus there has come, then, a varied topography, consisting of morainic uplands, level bottoms of extinct post-Glacial lakes, and modern alluvial flats. The lowering of water in the larger lake basins appears still to be in progress, as shown by the writer's studies on the shore lines of Athabasca and Great Slave Lakes.[2] The drainage of smaller basins, such as that of the morainically dammed Moose and Bog Lakes, is also still in progress, by the further cutting of their barriers.

The Distribution of the Vegetation

The country south and west of Fort Smith, and the lowland areas of the lower Athabasca and Peace Rivers are sufficiently well known for the construction of a generalized map of their vegetations (Fig. 8). In addition to his own observations the writer has drawn from those of several keen observers. Charles Camsell, in 1902, made reconnaissance journeys between Ft. Smith and the Peace River by way of the Little Buffalo and Jackfish Rivers, and between Ft. Smith and Moose

[1] Kindle, E. M. *Notes on Sedimentation in the Mackenzie Basin.* Journ. Geol. xxvi. 341–360 (1918).

[2] Raup, Hugh M. *The Vegetation of the Fort Reliance Sand Plain*, and *A Survey of the Vegetation of Shelter Point, Athabasca Lake.* Univ. of Pittsburgh Bull. xxv. 75–83 (Oct. 25, 1928).

Lake by an overland route.[1] His description of the country is excellent. E. T. Seton and E. A. Preble visited the salt plains and upland southwest of Ft. Smith in 1907, in search of the wood bison, and Mr. Seton's report contains a brief description of the country.[2] For a number of years prior to 1922, Mr. F. V. Seibert made a series of journeys over a large part of the country west of the Slave and Little Buffalo Rivers, between the Peace and the Nyarling. His map and description of the area have been very useful.[3] Later maps made by the Topographical Survey of Canada, especially the aerial photographic ones which cover a part of the region, have added much information which would be obtainable in no other way.

The arrangement of the main boundaries of the types of vegetation in the area thus far examined shows a striking similarity to that of the shores and bottoms of the post-Glacial Lakes (See Figures 6, 7, and 8).

The heavily timbered areas are confined to the upland which stood above the 800-foot lake. The timber is best developed upon the rolling morainic areas whose soils are largely sandy and gravelly, well drained. In the northeastern section of this upland heavier soils occur, with a large amount of clay. On this there is an abundance of prairie openings. The dry ridges have a forest of *Pinus Banksiana*, with a lichen and trailing shrub mat. Where the soils are not so completely drained, as on lower slopes or in hollows, a *Picea canadensis* timber has arisen, with a moss and humus mat and a light shrub cover. Extensive burning has introduced much deciduous timber of *Populus tremuloides* and *P. balsamifera*, and a rich growth of shrubs and perennial herbs. Prairie openings are margined by willows and have a close turf of short grasses mixed with other prairie herbs.

The upland vegetation is varied by muskeg forest and slough where the drainage of depressions has not been good. *Picea mariana* and *Larix laricina* are the prevailing trees at muskeg margins, while *Betula glandulosa* and various willows make up a shrub zone. Much of the country is underlain by a gypsiferous, Silurian limestone, which has brought about extensive sink hole formation. Completely

[1] Camsell, Charles. *The Region Southwest of Fort Smith, Slave River, N. W. T.* C. G. S. Ann. Rept. xv. 115A.

[2] Seton, E. T. *The Arctic Prairies.* New York, Charles Scribner's Sons (1911).

[3] Seibert, F. V. *Map Showing the Interior Topography of the Wood Buffalo Park.* Natural Resources Intelligence Service, Dept. of Interior, Canada.

———, —. —. *Canada's Wild Buffalo,* Appendix, *A Reconnaissance Survey in the Home of the Wood Buffalo.* Dept. of Interior, Canada, Northwest Territories and Yukon Branch (1922).

undrained holes have permanent lakes or bogs in them, while completely drained ones have a vegetation similar to their surroundings.

Figs. 6 and 7. Probable lake expansions in the lower Athabasca-lower Peace-upper Slave River district when the water stood at the 800-foot (6) and 700-foot (7) levels. (Modified from *A. E. Cameron.*)

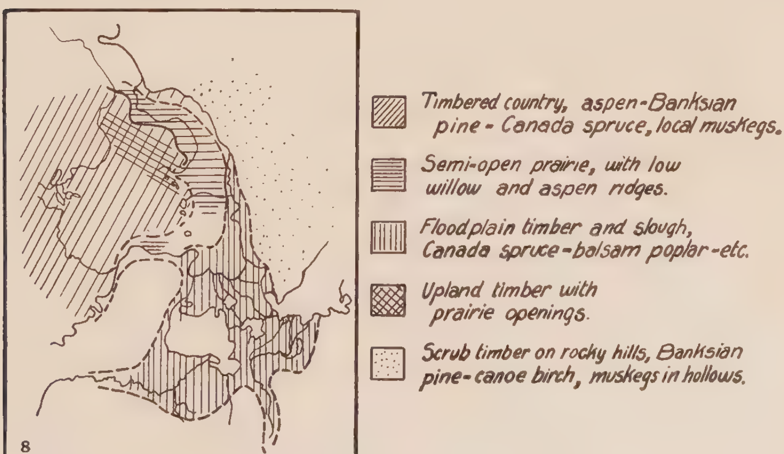


Fig. 8. Map of the vegetation in the lower Athabasca-lower Peace-upper Slave River region.

Holes with fluctuating water levels have a semi-prairie type of vegetation consisting of grasses, sedges, and other herbs, much like that of the prairie openings.

The exposed bottom of the lake which stood at about the 800-foot level has an extensive semi-open prairie country. There are low, willow-covered ridges here and there, with wide, grassy prairie spaces between them. Slightly lower areas contain a marsh vegetation except where the spring and early summer outwash from the salt springs to the westward has stood for some time and made a thin saline deposit. Such areas have a typical salt flat vegetation or are completely barren. The prairies are broken in a few places by sandy ridges which are apparently morainic in origin, and whose positions have not been mapped.

The river banks in the alluvial lowlands, formed by natural levees, have a deep forest of *Picea canadensis,* of which *Populus balsamifera* is a forerunner in the flood plain succession. Abandoned channels and other ponded areas left partially drained by the river's meanderings have an extensive vegetation of sedges and grasses, the former predominating. The newest bars of sand and mud have a willow and *Equisetum* cover.

On the pre-Cambrian upland to the east of Slave River there is a scrub timber of *Pinus Banksiana* and *Betula alaskana.* There is a rich growth of crustose, foliose, and fruticose lichens on the barren hill-tops and in crevices.

The forest on the tops of the Cretaceous plateau areas has not been studied, except for a few observations and collections about the Clearwater-McMurray district. Subsequent notes will show that this varies from that of the Slave River district, having a richer moss and humus mat.

The richest forest in the glacial lake district is that of *Picea canadensis.* It is developed on the better soils of the oldest uplands and upon the better drained parts of the newest alluvial flats. In neither of these is there a leaf mould much exceeding 4 inches in thickness, beneath a moss mat 4 or 5 inches deep at its best development.

Affinities of the Flora of the Athabasca-Great Slave Lake Region

The entire vegetation of the Athabasca-Great Slave Lake district having been removed by the Pleistocene ice, the present flora is a new structure which has been in process of growth since that time. This growth has been slow for two main reasons. The sub-arctic climate with its short growing season is an efficient check. Not only

are the life processes of the plant cover greatly retarded throughout a large part of the year, but also the processes of decay. Dead wood and other plant parts remain for many years without showing signs of disintegration. Axe cuts appear fresh a year after they are made. This condition is reflected in the small amount of humus accumulation in the oldest forests. Descriptions of forests in more southern glaciated regions such as those of Isle Royale[1] indicate that a much larger amount of humus has accumulated there. The climate, tending to retard the development of humus in the soil, is probably an important factor in the production of the relatively thin forests.

The presence of the Glacial lakes, persisting for a long time after the ice had begun to recede, kept large areas from beginning their vegetational development. How long this was in the case of the larger lakes is uncertain. The length of time involved since the retreat of the ice is also unestimated. The country is near the source of ice accumulation, and may have been exposed at a comparatively recent time. Smaller lake basins, such as that of Moose and Bog Lakes, show unmistakable signs, in the present shore lines and in neighboring muskeg and sand ridge areas, of having reached their present level very recently. Extensive areas, then, have acquired their vegetation, much of it spruce forest with a very thin moss and humus carpet, in comparatively recent times, the climatic and time factors appearing to be the most influential in producing the present condition.

In the neighborhood of Fort McMurray, where the Clearwater River enters the Athabasca, there are highlands of Cretaceous rocks upon which there is a thick forest involving not only *Picea canadensis* but also its associate in other regions, *Abies balsamea.* On the upper Clearwater the latter tree is reported to be common by John Macoun, who traversed that region in 1876.[2] More will be found concerning the distribution of this species in another part of the paper.

Into this comparatively young area, with its slowly developing mesophytic conditions, have come plants from widely separated regions. Certain species of *Salix*, *Carex*, and various Gramineae

[1] Cooper, W. S. *The Climax Forest of Isle Royale, Lake Superior, and its Development.* Bot. Gaz. lv. 16 (1913).

[2] Macoun, John. *On the Botanical Features of the Country Traversed from Vancouver Island to Carleton, on the Saskatchewan.* C. G. S. Rept. of Progress (1875–76), 172. (This report contains a good description of the vegetation of the lower Peace and Athabasca Rivers and their deltas.)

have been selected to illustrate these ranges, though other groups could be used equally well. A few other selected species have been used to bring out further the main features. Material in the Gray Herbarium has served as the basis for the maps given, and has been supplemented with records from other sources, carefully examined to eliminate errors. The maps are far from complete, but the writer believes that they are sufficiently representative to indicate the ranges.[1]

A wide-ranging arctic and arctic-alpine flora is represented by *Salix reticulata* (Fig. 10), *Agrostis borealis* (Fig. 11), and *Carex membranacea* (Fig. 9). These species enter the region in the northern and eastern parts of the Great Slave Lake area, where they join such species of eastern American arctic affinity as *Carex supina* (Fig. 13) and *Carex glacialis* (Fig. 12), and with Alaskan-Asiatic species such as *Cypripedium guttatum* (Fig. 14), *Salix alaxensis* (Fig. 15), and *Boschniakia glabra* (Fig. 16). The writer has collected these species on bleak shores and rock hills, or in cold muskegs.

Another group of species is widely distributed from Alaska or western Yukon southward in the mountains and eastward in the great plains regions. It is represented in the Athabasca-Great Slave Lake district by *Bromus Pumpellianus* (Fig. 19), *Stipa comata* (Fig. 17), *Elymus innovatus* (Fig. 18), *Carex obtusata* (Fig. 21), *C. Rossii* (Fig. 20), *Salix lasiandra* (Fig. 22), and *Trientalis arctica* (Fig. 23). *Stipa comata* and *Carex obtusata* have been collected by the writer only in the small prairie area at Peace Pt., on the lower Peace River. *Bromus Pumpellianus* and *Elymus innovatus* are very common species of upland poplar woods. *Trientalis arctica* was collected in 1926 by Mr. John Russel, at the junction of the Nyarling and Little Buffalo Rivers. *Carex Rossii* grows in upland aspen woods along the Slave River, while *Salix lasiandra* is a rather common species in river flood plain deposits.

Southern mountain and great plains floras have contributed *Poa arida* (Fig. 24), *Spartina gracilis* (Fig. 25), *Fluminea festucacea* (Fig. 26), *Agropyron Smithii* var. *molle* (Fig. 27), and *Salix lutea* (Fig. 28). *Poa arida, Spartina gracilis,* and *Agropyron Smithii* var. *molle* are to be found in the semi-open prairie areas along the lower Peace and west of the Slave River. *Fluminea festucacea* makes up an important

[1] The ranges in figs. 9–37 are on a base map by J. Paul Goode, published by the University of Chicago Press.

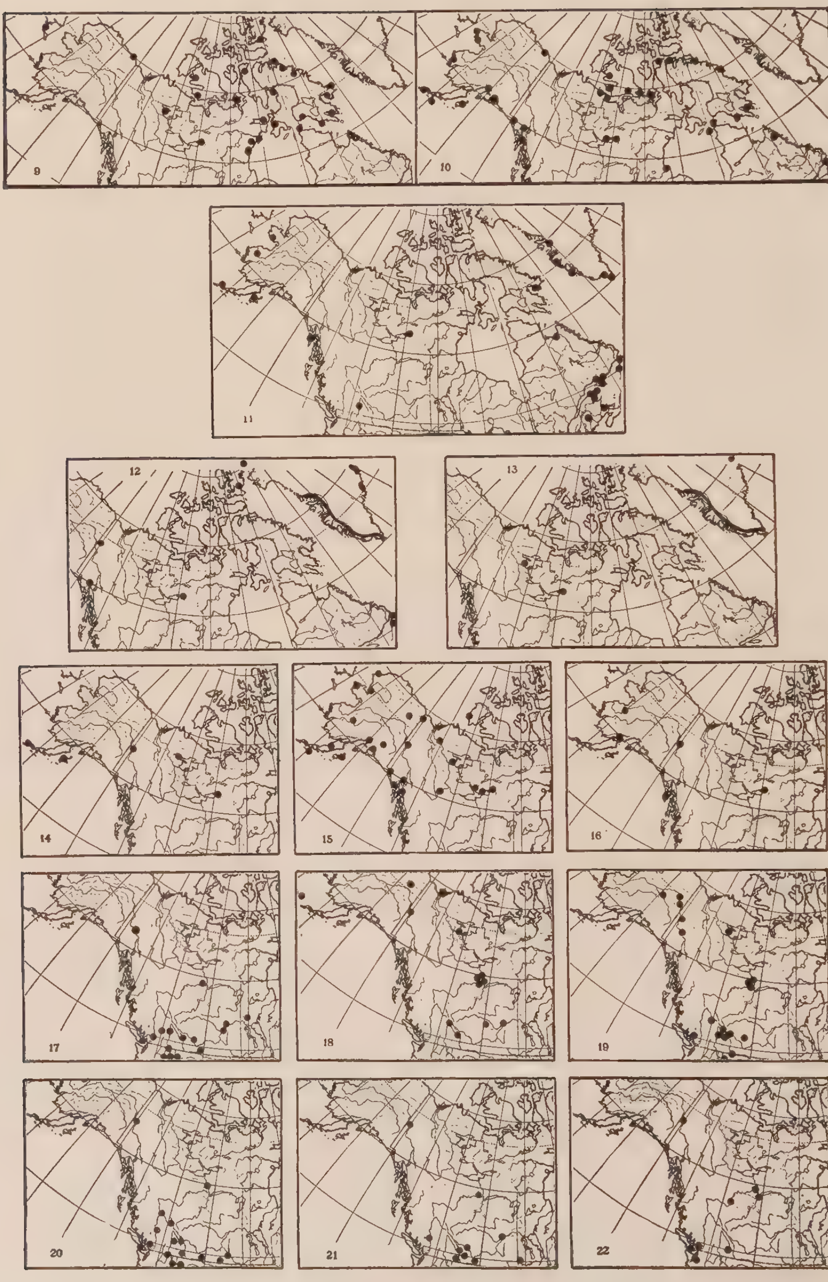
part of the flora of the flood plain meadows along the larger rivers, and is an emergent aquatic species on the gently sloping shores of Moose Lake. *Salix lutea* is a prominent flood plain willow in the Peace-Athabasca delta.

Western mountain species which range eastward to Ontario and New York are *Carex Richardsonii* (Fig. 29) and *C. trichocarpa* var. *aristata* (Fig. 30). The former was collected in dry upland woods along the upper Slave River, and the latter is the most important plant cover of the meadow sloughs in the river flood plains. It here covers many square miles in nearly pure stands. At Moose Lake it was found associated with *Fluminea festucacea* as an emergent aquatic marsh plant.

Species with a wide range from northeastern New England, New Brunswick, or the St. Lawrence district to the Cordilleran region, having their greatest northwestward extension in the Athabasca-Great Slave Lake country are *Pinus Banksiana, Muhlenbergia Richardsonis* (Fig. 31), *Carex Sartwellii* (Fig. 32), *C. arcta* (Fig. 34), and *Salix petiolaris* (Fig. 33). *Pinus Banksiana* makes up the timber on the dry ridges of the uplands in the southern part of the district under consideration. On the northern and eastern shores of Great Slave Lake, however, it nearly disappears, and its place is taken by *Picea canadensis*. *Muhlenbergia Richardsonis* is a plant of salt-flat margins west of the upper Slave River. *Carex Sartwellii* and *C. arcta* have been collected in the prairie along the lower Peace, at Peace Pt. *Salix petiolaris* grows in the flood plain sloughs along the upper Slave River.

The major trees of the Canadian forest are widely distributed from Newfoundland to Alaska, *Picea canadensis, P. mariana, Populus tremuloides,* and *P. balsamifera*. In the Athabasca-Great Slave Lake district *Picea canadensis* is the tree which forms the deepest, most permanent timber, while the poplars are prominent in burned areas. *Populus balsamifera* is a notable tree, also, in the earlier stages of the flood plain and delta timber. *Picea mariana* is confined to muskeg forest. *Glyceria grandis* (Fig. 37) and *Carex tenuiflora* (Fig. 35) are herbaceous species of similar wide-ranging tendencies. *Glyceria grandis* is prominent on the margins of slough ponds, while *Carex tenuiflora* is an inhabitant of cold bogs.

On the sandy beaches of Lake Athabasca is found *Elymus arenarius* var. *villosus* (Fig. 36). It is a widely distributed plant of extensive sandy shores, chiefly maritime. It enters the continent along the main inland waterways.



Maps showing the ranges of: (9) *Carex membranacea* Hook.; (10) *Salix reticulata* L.; (11) *Agrostis borealis* Hartm.; (12) *Carex glacialis* Mack.; (13) *C. supina* Wahl.; (14) *Cypripedium guttatum* Swartz; (15) *Salix alaxensis* (And.) Cov.; (16) *Boschniakia glabra* C. A. Meyer; (17) *Stipa comata* Trin. & Rup.; (18) *Elymus innovatus* Beal; (19) *Bromus Pumpellianus* Scribn.; (20) *Carex Rossii* Boott; (21) *C. obtusata* Liljebl.; (22) *Salix lasiandra* Benth.

Maps showing the ranges of: (23) *Trientalis arctica* Fisch.; (24) *Poa arida* Vasey; (25) *Spartina gracilis* Trin.; (26) *Fluminea festucacea* (Willd.) Hitchc.; (27) *Agropyron Smithii* Rydb., var. *molle* (Scribn. & Smith) Jones; (28) *Salix lutea* Nutt.; (29) *Carex Richardsonii* R. Br.; (30) *C. trichocarpa* Muhl., var. *aristata* (R. Br.) Bailey; (31) *Muhlenbergia Richardsonis* (Trin.) Rydb.; (32) *Carex Sartwellii* Dewey; (33) *Salix petiolaris* Smith; (34) *Carex arcta* Boott; (35) *C. tenuiflora* Wahlenb.; (36) *Elymus arenarius* L., var. *villosus* E. Mey.; (37) *Glyceria grandis* Wats.

On the Absence of Certain Canadian Forest Plants from the Athabasca-Great Slave Lake Region

Four summer's botanizing in the Athabasca-Great Slave Lake district, together with a study of the distribution of certain common Canadian forest species, have shown that there is a conspicuous absence of some plants which are otherwise of very wide distribution. This wide distribution is not entirely limited to temperate regions.

Making use of Cooper's studies in the flora of Isle Royale, Lake Superior,[1] and more especially of Professor M. L. Fernald's extensive knowledge of the flora of northeastern North America, a list of plants has been constructed, which are common in the rich woodlands of eastern Canada. By means of the material in the Gray Herbarium and other records the ranges of these species have been arranged in five groups, as shown in the table, Fig. 38. Group A includes eastern species which reach westward only as far as the forests of northern Manitoba. They are mainly plants of the rich forests which extend from Newfoundland to Ontario. A few, such as *Abies balsamea, Acer spicatum, Osmorhiza Claytoni,* and *Trientalis borealis,* are known in northern Saskatchewan and Alberta. Group B consists of species which are known from the lower St. Lawrence district and in the mountains of British Colombia, Washington, or Oregon, but are not known in Alaska or in the Athabasca-Great Slave Lake district. Group C is of species ranging northwestward into the Athabasca-Great Slave Lake district, but not into the British Columbia and Alberta mountains. A small group, D, contains species which range westward into the Cordillera and into the Athabasca-Great Slave Lake district, but not to Alaska. Group E contains species which extend from the lower St. Lawrence country to the mountains of British Columbia or western Alberta and north to Alaska or western Yukon, but which do not enter the Athabasca-Great Slave Lake region. A sixth group, F, is of species known throughout the Canadian forest region.

Carex Deweyana is recorded for the Mackenzie basin,[2] but the writer has not collected it in the area under discussion. *Thelypteris Dryopteris,*[3] *Trillium cernuum* var. *macranthum,*[4] and *Cypripedium acaule*[5]

[1] Cooper, W. S. *The Climax Forest of Isle Royale, Lake Superior, and its Development.* Bot. Gaz. lv. Nos. 1, 2, 3 (1913).

[2] Rydberg, P. A. *Flora of the Rocky Mountains and Adjacent Plains.* Second edition, 127 (1922).

[3] Hooker, W. J. *Flora Boreali-Americana,* ii. 259 (1840).

[4] ———, —. —. Ibid. ii. 180.

[5] ———, —. —. Ibid. ii. 204.

have not been collected by the writer, but are reported for the Mackenzie region in *Flora Boreali-Americana.* There are specimens of *Trillium cernuum* var. *macranthum* and *Cypripedium acaule* in the Gray Herbarium, collected by Richardson and labeled "Mackenzie River," and "Fort Franklin," respectively. The occurrence of these plants so far northward of their better-known ranges is worthy of note. *Pyrola minor* is reported by Dr. Richardson[1] as occurring in the barren country between latitude 64° and the arctic coast, but has not been turned up in the Athabasca-Great Slave Lake region.

TABLE SHOWING THE DISTRIBUTION OF CANADIAN FOREST PLANTS

	A	B	C	D	E	F
Thelypteris Dryopteris (L.) Slosson					*	
T. Phegopteris (L.) Slosson					*	
T. spinulosa (O. F. Muell.) Nieuwland					*	
Osmunda Claytoniana L.	*					
Equisetum sylvaticum L.						*
E. arvense L.						*
E. scirpoides Michx.						*
Lycopodium lucidulum Michx.		*				
L. annotinum L.						*
L. obscurum L.					*	
L. complanatum L.						*
Taxus canadensis Marsh.	*					
Picea canadensis (Mill.) BSP.						*
Abies balsamea (L.) Mill.	*					
Poa saltuensis Fernald & Wiegand	*					
Cinna latifolia (Trev.) Griseb.					*	
Carex Deweyana Schwein		*				
Clintonia borealis (Ait.) Raf.	*					
Maianthemum canadense Desf.			*			
Streptopus roseus Michx.					*	
S. amplexifolius (L.) DC.					*	
Trillium cernuum L.	*					
T. undulatum Willd.	*					
Cypripedium parviflorum Salisb.		*				
C. reginae Walt.	*					
C. acaule Ait.	*					
Habenaria orbiculata (Pursh) Torr.					*	
Epipactis repens (L.) Crantz. var. ophioides (Fernald) A. A. Eaton			*			
E. tesselata (Lodd.) A. A. Eaton	*					
E. decipiens (Hook.) Ames					*	
Listera cordata (L.) R. Br.					*	
L. convallarioides (Sw.) Torr.						*
Corallorrhiza trifida Chatelain						*
C. striata Lindl.		*				
Calypso borealis Salisb.						*
Betula lutea Michx. f.	*					
Alnus crispa (Ait.) Pursh.			*			
Laportea canadensis (L.) Gaud.	*					

[1] Hooker, W. J. Ibid. ii. 45.

	A	B	C	D	E	F
Geocaulon lividum (Richards.) Fernald						*
Ranunculus recurvatus Poir.	*					
Coptis groenlandica (Oeder) Fernald	*					
Actaea rubra (Ait.) Willd.						*
Dicentra Cucullaria (L.) Bernh.		*				
Mitella nuda L.				*		
Tiarella cordifolia L.	*					
Ribes lacustre (Pers.) Poir.						*
R. prostratum L'Hér.				*		
R. triste Pall.						*
Amelanchier Bartramiana (Tausch.) Roem.	*					
Geum macrophyllum Willd.					*	
Rubus pubescens Raf.				*		
Oxalis montana Raf.	*					
Acer spicatum Lam.	*					
A. pennsylvanicum L.	*					
A. saccharum Marsh.	*					
A. rubrum L.	*					
Viola pallens (Banks) Brainerd					*	
V. incognita Brainerd	*					
V. renifolia Gray		*				
Circaea alpina L.					*	
Aralia nudicaulis L.						*
Osmorhiza obtusa (Coult. & Rose) Fernald					*	
O. Claytoni (Michx.) Clarke	*					
O. divaricata Nutt.					*	
Conioselinum chinense (L.) BSP.	*					
Cornus canadensis L.						*
Moneses uniflora (L.) Gray						*
Pyrola minor L.					*	
P. secunda L.						*
P. chlorantha Sw.				*		
P. elliptica Nutt.		*				
P. asarifolia Michx.						*
Monotropa uniflora L.						*
Epigaea repens L.	*					
Chiogenes hispidula (L.) T. & G.		*				
Vaccinium ovalifolium Sm.					*	
Trientalis borealis Raf.	*					
Orobanche uniflora L.		*				
Galium kamtschaticum Steller.					*	
G. triflorum Michx.						*
Lonicera canadensis Marsh.	*					
Linnaea borealis L. var. americana (Forbes) Rehder						*
Viburnum pauciflorum Raf.						*
Solidago macrophylla Pursh.	*					
Petasites palmatus (Ait.) Gray				*		
Prenanthes altissima L.	*					

The table shows 27 species which are known in the forests of eastern Canada and in the Cordilleran region. 18 of these also range northward to Alaska or western Yukon, while none of the 28 enter the forests of the Athabasca-Great Slave Lake region. The records of

certain species in isolated localities in the more northern part of the Mackenzie basin indicate the possibility of there being a greater number of the otherwise absent species in restricted localities than is known at present.

The cause for the absence or great scarcity and evident localization of so large a number of species in these forests has not been found. If temperature were a controlling factor these species would not be expected to range so widely through temperate and sub-arctic climates. Due to the absence of the vegetable remains of such a condition, it is not probable that there has been, in former post-Glacial time, a more equable climate. The most profitable line of inquiry appears to be in the edaphic factors of the environment, especially in so far as they are affected by the rigorous climate and the short time available since much of the vegetation had its inception.

The small accumulation of vegetable remains in the forests, and the extremely slow rate of decay due to the severe climate have already been mentioned. It is evident from the discussion of the physiographic history of the country that practically the whole region was exposed at a much later time, after the recession of the ice, than were the Cretaceous uplands that border it. An important phase in the solution of the problem will be an extended study of these uplands.

It is of note that such a tree as *Abies balsamea*, which plays such a large part in the forests of Ontario, should find its northern limit in the Athabasca valley approximately at the margin of the Cretaceous upland. Although it has been reported at isolated spots farther northward, the records need verification. The writer has visited the site of one of these records, in the limestone gorge of the Little Buffalo River, west of Ft. Smith, but has been unable to find the trees. If there are but few individuals there, however, they could very easily have been missed. This locality has the richest forest which the writer has seen in the region, a condition probably due to the presence of the gorge with its falls, and the resulting moisture-laden atmosphere that prevails. Sir John Richardson reported the tree at latitude 62°, but was not specific about the locality. It is very common, however, on the uplands about the Clearwater River, as has been stated above. The break in the deep forest conditions along the lower Athabasca is not confined to the trees, although a thorough study has not been made of the situation. Such herbaceous

species as *Disporum trachycarpum* S. Wats. and *Trientalis americana* (Pers.) Pursh also have their northern limit in this district.

Hutchinson's studies in the forests of Ontario indicate that the advance of mesophytic conditions, embodied in the development of a deciduous forest, has lagged behind temperature changes in post-Glacial time, and awaits the slower development of soils.[1] The forests of the Athabasca-Great Slave Lake region may present the same situation in an earlier stage of successional development.

Gray Herbarium,
Harvard University.

THE FLORA OF THE ELIZABETH ISLANDS, MASSACHUSETTS

John M. Fogg, Jr.

(*Continued from page 180*)

Native plants. The 558 species of indigenous plants on the Elizabeth Islands fall rather clearly into three fairly well differentiated categories. In the first place, there is the southern element—plants of the southern coastal plain which range north from Florida or the Gulf States to achieve their northern limit in southeastern Massachusetts, some of them passing on to Nova Scotia or Newfoundland; then there is a group of species of northern affinities, many of which have already been mentioned in speaking of Nantucket and Cape Cod, which range south or southwest to Massachusetts or, at most, New Jersey. And, finally, there is a large and very important block of plants which fall into neither of the two preceding classes, but belong rather to a continental upland flora than to that which characterizes the lowlying reaches of most of Cape Cod and the adjacent islands. It will be well to analyze briefly the constituents of these three groupings before proceeding further.

The Southern Element. In rather striking contrast to the situation found on Nantucket, where, it will be remembered, over 50% of the indigenous flora is prevailingly more southern in its hue, as well as on the middle part of Cape Cod, where, as has been seen, the native flora is preëminently that of the southern coastal plain, is the

[1] Hutchinson, A. H. *Limiting Factors in Relation to Specific Ranges of Tolerance of Forest Trees.* Bot. Gaz. lxvi. 465–493 (1918).

fact that on the Elizabeth Islands this southern element finds expression in something less than 20% of the total indigenous flora.

It is true that there are a few species of plants of the southern coastal plain which, on the Elizabeth Islands are near the very northeastern limit of their distribution. *Paspalum setaceum*, for example, is known in Massachusetts only from the Elizabeths and Nantucket.[1] *Panicum longifolium* is found nowhere east of Pasque Island, at which place it is abundant in the peaty bog hollows,[2] although it is represented in Nova Scotia by var. *tusketense*.[3] *Tipularia discolor* is near the northeastern limit of its range on one of the Elizabeth Islands (Nashawena) and on Martha's Vineyard. *Rumex verticillatus*, long known from Block Island, but otherwise rare in New England, has recently been collected on the Elizabeths. *Hydrocotyle Canbyi* and *H. verticillata*, both known on the basis of old records from Woods Hole (for years their only known station in New England) have, during the course of the present survey, been discovered on the Elizabeth Islands as well. *Solidago minor* ranges from Alabama and Florida to Virginia, then "jumps" to Nantucket, where it was reported by Bicknell, and is now known to occur on Naushon, the largest of the Elizabeths. Thus it will be seen, that these islands, as is true of nearly every other locality along the coast from New Jersey northward, are not totally lacking in records which represent interesting, or even spectacular, northern extensions of plants which are essentially southern in their affinities.

In general, however, the flora of the Elizabeth Islands far from suggests that of the coastal plain. The following enumeration, which includes the seven species just mentioned, constitutes a nearly complete list of the plants known from these islands which are also characteristic species of the coastal strip, ranging from the Gulf States, Florida or Georgia northeastward. Many of them, of course, continue farther north and east, being known from Nova Scotia, New Brunswick or even Newfoundland, but they are, for the most part, plants of a pronounced austro-riparian origin. It would be difficult to make such a list comprehensive, for, in the absence of adequate data concerning the complete ranges of every species, it is not always easy to state categorically whether a plant belongs exclusively to the southern coastal plain, or whether it enjoys an Alleghanian-Carolin-

[1] See Weatherby, Rhodora, xxx. 133 (1928).
[2] See Fogg, Rhodora, xxxi. 39 (1929).
[3] See Fernald, Rhodora, xxiii. 192 (1921).

ian distribution. All of the species listed below, with the exception of those marked with an asterisk, are known also from Cape Cod.

Woodwardia virginica
Thelypteris simulata
Lycopodium inundatum, var. Bigelovii
Chamaecyparis thyoides
Sparganium eurycarpum
Potamogeton Oakesianus
P. pulcher
Andropogon scoparius, var. polyclados
A. virginicus
*Paspalum setaceum
P. pubescens
Panicum meridionale
P. albemarlense
P. oricola
*P. longifolium
P. Commonsianum
Setaria geniculata
Cenchrus pauciflorus
Stipa avenacea
Aristida purpurascens
Ammophila breviligulata
Spartina alterniflora, var. pilosa
*Diplachne maritima
Cyperus erythrorhizos
C. ferax
Eleocharis rostellata
Fimbristylis autumnalis
Scirpus Olneyi
S. robustus
Rynchospora capitellata
Carex Longii
C. straminea
C. alata
C. Howei
C. Mitchelliana
Xyris caroliniana
Juncus effusus, var. costulatus
Luzula campestris, var. echinata
Smilax rotundifolia
Iris prismatica
Sisyrinchium graminoides
Pogonia ophioglossoides
Calopogon pulchellus
*Tipularia discolor
Myrica caroliniensis
Spergularia rubra
Boehmeria cylindrica, var. Drummondiana
*Rumex verticillatus
Polygonum glaucum
P. punctatum
Drosera intermedia
Pyrus arbutifolia
Rubus Andrewsianus
Rosa palustris
Prunus maritima
Desmodium obtusum
D. marilandicum
Lespedeza capitata
Polygala cruciata
Euphorbia polygonifolia
Ilex opaca
I. glabra
Hibiscus Moscheutos
Hypericum virginicum
Helianthemum canadense
H. Bicknellii
Lechea villosa
L. maritima
Decodon verticillatus
Rhexia virginica
Myriophyllum scabratum
Proserpinaca palustris
*Sanicula canadensis
Hydrocotyle umbellata
H. Canbyi
H. verticillata
Ptilimnium capillaceum
Clethra alnifolia
Rhododendron viscosum, var. glaucum
Leucothoe racemosa
Samolus floribundus
Bartonia virginica
B. paniculata
Nymphoides lacunosum
Asclepias verticillata
Teucrium canadense, var. littorale
Ilysanthes inaequalis
Gratiola aurea
Agalinis maritima
Utricularia gibba
*Plantago virginica

Eupatorium hyssopifolium
Solidago Elliottii
*S. minor
S. tenuifolia
Aster dumosus
A. vimineus
Pluchea camphorata
Gnaphalium purpureum
Coreopsis rosea
Krigia virginica
Lactuca hirsuta
Hieracium Gronovii

A point requiring particular emphasis is, that many of these species are by no means common on the islands. Indeed, a few of them, such as *Thelypteris simulata, Paspalum setaceum, Panicum longifolium, P. Commonsianum, Cenchrus pauciflorus, Diplachne maritima, Eleocharis rostellata, Carex straminea, C. alata, C. Mitchelliana, Luzula campestris*, var. *echinata, Tipularia discolor, Rumex verticillatus, Prunus maritima, Ilex glabra, Sanicula canadensis, Hydrocotyle Canbyi, Rhododendron viscosum*, var. *glaucum, Triosteum perfoliatum, Solidago minor* and *Coreopsis rosea*, are known only from a single locality, while certain others, though less restricted, are nevertheless rare and local. And seldom, if ever, are these coastal plain plants present in sufficient abundance to create the impression, inescapable on Cape Cod, of a southern flora transplanted almost *en masse*.

Pursuing this last idea further, it will be found interesting to contrast with the list just given a list of some of the southern coastal plain plants which are known to occur on Cape Cod (most of them from the Middle Cape), but which have not yet been found on the Elizabeth Islands:

Pteridium aquilinum, var. pseudocaudatum
Sagittaria Engelmanniana
S. graminea
S. teres
Paspalum psammophilum
Panicum verrucosum
P. Bicknellii
P. microcarpon
P. annulum
P. mattamuskeetense
P. spretum
P. Wrightianum
P. auburne
P. tsugetorum
P. columbianum
P. polyanthes
P. Ashei
P. scoparium
Aristida dichotoma
A. gracilis
Spartina cynosuroides
Tridens flavus
Cyperus filicinus, var. microdontus
C. Grayii
Eleocharis Robbinsii
E. melanocarpa
Psilocarya scirpoides
Scirpus atrovirens, var. georgianus
S. Eriophorum
Fuirena squarrosa
Hemicarpha micrantha
Rynchospora macrostachya
R. inundata
R. Torreyana
R. capitellata, var. discutiens

Scleria reticularis
Carex annectens
C. intumescens
C. bullata, var. Greenei
Arisaema Stewardsonii
Peltandra virginica
Orontium aquaticum
Xyris Smalliana
Juncus subcaudatus
J. aristulatus
Lilium superbum
Aletris farinosa
Lachnanthes tinctoria
Myrica asplenifolia
Quercus stellata
Q. prinoides
Q. ilicifolia
Comandra umbellata
Polygonum setaceum
Polygonella articulata
Acnida cannabina
Drosera filiformis
Cassia Chamaecrista
Crotalaria sagittalis
Lupinus perennis
Tephrosia virginiana
Desmodium rotundifolium
D. marilandicum
Lespedeza procumbens
L. Stuvei
L. angustifolia
Strophostyles helvola
Linum floridanum, var. intercursum
Polygala Nuttallii
Corema Conradii
Acer rubrum, var. tridens
Ceanothus americanus, var. intermedius
Vitis cordifolia
Hypericum adpressum
Hudsonia ericoides
Viola emarginata
V. primulifolia
Opuntia vulgaris
Rhexia mariana
Oenothera linearis
O. longipedicellata
Proserpinaca pectinata
P. intermedia
Lilaeopsis chinensis
Sabatia campanulata
Cuscuta compacta
Onosmodium virginianum
Stachys hyssopifolia
Lycopus sessilifolius
Agalinis purpurea
Aureolaria pedicularia, var. caesariensis
Utricularia inflata
U. subulata
Viburnum pubescens
Eupatorium verbenaefolium
Mikania scandens
Solidago erecta
S. puberula
Aster spectabilis
A. subulatus
A. tenuifolius
Baccharis halimifolia
Bidens coronata
Lactuca floridana

Thus it will be seen that, while there occur on the Elizabeth Islands something like 100 species belonging to a wideranging southwestern flora, Cape Cod not only has practically every one of these same plants, but boasts in addition at least an equal number of species of the same class which, so far as is known, are totally lacking from the islands.

It may be worth while to note, in passing, that, while an overwhelmingly large proportion of the more than 200 prevailingly southern species which occur on Cape Cod occur likewise on Nantucket (and a considerably smaller proportion on Martha's Vineyard), that island has caught a number of these southern migrants which appear not to have succeeded in reaching the Cape. Several of these may be listed:

Eleocharis tricostata
Scleria triglomerata
Carex Walteriana
Habenaria ciliaris
Quercus pagodaefolia
Polygonum robustius
Amaranthus pumilus
Ranunculus laxicaulis
Ascyron hypericoides
Lespedeza virginica
Lechea Leggettii
Ludvigia alterniflora
Pycnanthemum verticillatum
Schwalbea americana
Aster concolor

Sufficient evidence has probably been adduced to bear out the contention that the relations of the flora of the Elizabeth Islands to that of the southern coastal plain are anything but prominently marked, and that this southern, or southwestern, element is much more strongly represented in the closely adjacent regions, especially Cape Cod and Nantucket. An attempt to determine the causes which account for this break in distribution will shortly be made.

The Northern Element. Although lacking many of the northern types which distinguish the floras of parts of Nantucket and the "Lower" Cape, the Elizabeth Islands are not entirely without their representation of plants whose affinities are prevailingly boreal. In all, about 50 such species, constituting nearly 9% of the total native flora, may be considered as belonging to this class. It is significant to contrast this number with the 150 northern plants (over 20%) listed by Bicknell for Nantucket.

In general, these northern species which occur on the Elizabeth Islands are plants which range from Labrador and Newfoundland south to Massachusetts and New Jersey or, in a few cases, Delaware or Maryland. Many of them range south of New England along the mountains but reach the coastwise southern limit of their distribution in Massachusetts, Long Island or New Jersey. In the list which follows those species marked with an asterisk are to be looked upon as essentially maritime.

*Ruppia maritima, var. subcapitata
*Triglochin maritima
*Agrostis stolonifera, var. compacta
Spartina Michauxiana
Glyceria obtusa
G. canadensis
*Puccinellia paupercula, var. alaskana
Eleocharis uniglumis
Scirpus campestris, var. paludosus
Eriophorum tenellum
Rynchospora fusca
Carex hormathodes
C. silicea
C. canescens, var. disjuncta
C. limosa
C. lanuginosa
Eriocaulon septangulare
Juncus pelocarpus
J. militaris
J. articulatus
Sisyrinchium angustifolium
Liparis Loeselii
Betula populifolia

*Rumex maritimus, var. fueginus
Arenaria lateriflora
Sagina procumbens
*Ranunculus Cymbalaria
Drosera rotundifolia
Fragaria virginiana, var. terrae-novae
*Potentilla pacifica
*Lathyrus maritimus
Rhus glabra, var. borealis
Ilex verticillata, var. fastigiata
Hypericum boreale
Epilobium palustre, var. monticola
Myriophyllum tenellum
*Ligusticum scothicum
*Coelopleurum lucidum
Menyanthes trifoliata, var. minor
Chamaedaphne calyculata
Vaccinium macrocarpon
Limosella subulata
*Plantago juncoides, var. decipiens
Anaphalis margaritacea

The Elizabeth Islands, then, appear to have received their share of those far-ranging northern types which probably owe their existence in coastal New England, and southwestward, to the former presence of the broad continental shelf, already referred to, which permitted of their extension to the southwest and then, following its submergence, left them stranded at isolated localities along the coast. This would also explain why these islands possess fewer such plants than Martha's Vineyard (see p. 173) and still fewer than either Nantucket or the outer portion of Cape Cod. For, if these boreal species reached southeastern New England from off the elevated coastal bench to the eastward, then it seems logical to assume that a greater number of them would have found a refuge on Nantucket and the "Lower" Cape and that a smaller proportion would have succeeded in finding their way to the areas inland to the west, especially if, as may well have been the case, the retreat of the glacial ice from the latter region lagged appreciably behind its retreat from Nantucket, Martha's Vineyard and Cape Cod.

The Continental Element. It is only when we come to consider the continental element as it appears on the Elizabeth Islands that we find ourselves dealing with the type of vegetation which lends a dominating color to their flora. Probably more than 400 plants (about 70% of the total indigenous flora) from these islands are neither prevailingly southern nor northern in their distributional affinities but belong, rather, to a widespread continental flora which might be characterized, somewhat arbitrarily, as Canadian-Alleghanian in nature. This, it will be recognized immediately, is an attribute which the Elizabeths share in common with the upper or inner part of Cape Cod, and, indeed, there is every reason to suppose that the flora of these islands may, until comparatively recent geologic times, have been continuous with that of the line of hills which runs from

Falmouth to Bourne, and even north nearly to Plymouth. This entire ridge represents a terminal moraine which, beyond Cuttyhunk, dips below sea level reappearing, as some geologists believe, to form Block Island and, farther west, a portion of Long Island. The separation of the Elizabeth Islands from the mainland and their division into the seven present members of the chain are, as has already been indicated, relatively modern events. So it is entirely in keeping with the past history of this region that so many of the types which are abundant throughout the Falmouth area should likewise be common on the islands.

The relation of the flora of the Elizabeth Islands to that of the mainland comes out most clearly upon an examination of the forest types. The trees have already been listed (p. 151), but it seems entirely justifiable to repeat in this place that the native woods of the islands are made up not only of beech, *Fagus grandifolia* (surely not a coastal plain type), but also contain *Carya alba, Ostrya virginiana, Quercus alba, Q. velutina, Sassafras officinale, Hamamelis virginiana, Acer rubrum, Cornus florida* and *Nyssa sylvatica.* Now these trees, while they may and do occur on the coastal plain, are nevertheless more common and more clearly at home on the richer soils of the Piedmont and the areas inland, often reaching their finest development on wet wooded slopes and the alluvia of river valleys.

Under the trees listed above, on the wetter parts of the forest floor, occur such plants as *Carex lupulina, Arisaema triphyllum, Oakesia sessilifolia, Maianthemum canadense, Medeola virginiana* and *Trientalis borealis.* These again are types more commonly associated with an Alleghanian woodland flora. The beech drops, *Epifagus virginiana,* a rare plant in southeastern Massachusetts, occurs everywhere in the wooded parts of Naushon and Nashawena, and many other cases of this sort might be cited.

It would be superfluous to list here all of the species of Canadian-Alleghanian affinities which occur on the Elizabeth Islands. An enumeration of them would include most of the names of native plants in the Catalog that follows which have not been listed above in dealing either with the Southern or Northern Elements. A few of the most typical, however, not including the few trees mentioned above, may be given for the sake of comparison:

Polypodium virginianum	Athyrium angustum
Asplenium platyneuron	Osmunda cinnamomea

Ophioglossum vulgatum
Isoetes Engelmanni
Sparganium americanum
Sagittaria latifolia
Andropogon furcatus
Glyceria striata
G. pallida
Elymus virginicus
Cyperus diandrus
C. rivularis
Scirpus cyperinus
Eriophorum virginicum
Carex rosea, var. radiata
C. cephalophora
C. crinita
C. virescens
C. communis
C. pennsylvanica, var. separans
C. digitalis
C. debilis, var. Rudgei
C. lupulina
Arisaema triphyllum
Symplocarpus foetidus
Acorus Calamus
Juncus effusus, var. solutus
Oakesia sessilifolia
Lilium philadelphicum
Maianthemum canadense
Medeola virginiana
Habenaria bracteata
H. clavellata
H. orbiculata
Arethusa bulbosa
Boehmeria cylindrica
Polygonum scandens
Phytolacca americana
Ranunculus delphinifolius
Anemone virginiana
Coptis groenlandica
Spiraea tomentosa
Amelanchier oblongifolia
Geum canadense
Geranium maculatum
Acalypha virginica
A. digyneia
Callitriche heterophylla
Rhus typhina
R. Vernix
R. Toxicodendron
Ilex verticillata
Impatiens biflora
Vitis labrusca
V. aestivalis
Viola papilionacea
V. pallens
Ludvigia palustris
Cicuta maculata
Sium suave
Heracleum lanatum
Monotropa uniflora
M. Hypopithys
Epigaea repens
Gaultheria procumbens
Lysimachia quadrifolia
L. terrestris
Trientalis borealis
Apocynum androsaemifolium
Verbena hastata
Scutellaria galericulata
Pycnanthemum muticum
P. flexuosum
Epifagus virginiana
Cephalanthus occidentalis
Triosteum perfoliatum
Sambucus canadensis
Lobelia cardinalis
Solidago juncea
S. canadensis
Aster divaricatus
Cirsium discolor

The great bulk of these plants are species primarily of the interior; they attain their fullest development in the Piedmont and the Uplands and their occurrence on the coastal plain may be regarded, in most cases, as rather casual.

In summing up, it need merely be pointed out that the Elizabeth Islands, while serving, as does every other locality along the Atlantic coast, as a meeting ground for both northern and southern species of plants, exhibit both qualitatively and quantitatively a very strong

relationship with a widely dispersed flora of a continental nature, a fact which seems readily explicable upon the basis of the close connection existing between these islands and the inner, hilly part of Cape Cod, both as regards geologic history and general topography.

Finally, there remains to be considered, as briefly as may be, the subject of the last glacial advance over this region and its possible effects in influencing the present-day distribution of the flora.

Glacial History. Probably the greatest student of the geology of southeastern Massachusetts since the days of N. S. Shaler, was the late J. B. Woodworth of Harvard University. Professor Woodworth had prepared, shortly before his death, an exhaustive treatment of the glacial history of the Cape Cod region. This manuscript, unfortunately, still awaits publication and the details which it embodies are not yet available. Happily, however, Woodworth had related his broader conclusions to A. P. Brigham, geologist to Colgate University, and the main arguments are set forth by Brigham in his popular book entitled "Cape Cod and The Old Colony."

According to Woodworth, the advance of the last or Wisconsin ice over southeastern Massachusetts took place not as a solid sheet, but in the form of three tongues or lobes. One of these, the "Buzzards Bay Lobe," came down over the region now occupied by Buzzards Bay and deposited as a frontal moraine much of the material which now forms the line of high hills along the northwest shore of Martha's Vineyard, from Menemsha to West Chop. Then, following an interval which represented a retreat and a second advance of the ice, this lobe laid down, as a secondary moraine, the ridge which made the Elizabeth Islands and the "Upper Cape." The line of the islands, as may be seen from a map, almost exactly parallels the line of the morainal hills on the northwest shore of the Vineyard.

The second lobe, which lay to the east of the "Buzzards Bay Lobe," advanced southward over what is now the middle section of Cape Cod and laid down, as a terminal moraine, the sand, gravel and boulders which form the northeast shore of Martha's Vineyard and the higher, crescent-shaped portion of Nantucket. This Woodworth terms the "Cape Cod Lobe." This lobe then retreated, as did the Buzzards Bay Lobe and, as its secondary moraine, deposited the till which composes the "backbone" of Cape Cod from Sandwich to Brewster and Orleans. Thus, Martha's Vineyard was built by the combined action of two lobes and the central and southern parts of the island

represent an outwash or apron plain derived from two separate moraines. The southern and southeastern parts of Nantucket and almost the entire south shore of the Cape likewise represent outwash plains, both formed from the materials deposited by the Cape Cod Lobe.

Still further to the eastward, the third, or "South Channel Lobe" advanced over the area now submerged and known as Georges Banks. With the deposits of this lobe we are not so much concerned, as they now lie mostly beneath the sea, save for such materials as may have contributed to the building of the outer or lower part of Cape Cod. How far this lobe may have extended eastward over the then elevated continental shelf is apparently not definitely known.

It now becomes pertinent to inquire into the relative ages of these deposits and as to whether any evidence is forthcoming to indicate at what time and in what manner the various lobes retreated. Probably Woodworth's report, when it becomes available, will throw much light on this question. However, the writer has it on the authority of Dr. Wigglesworth of the Boston Society of Natural History, who is conversant with Woodworth's views, and who is himself a student of the geology of Martha's Vineyard, that in all probability the middle or Cape Cod lobe was the first one to retreat. If this was the case, it then means that Nantucket, the eastern part of Martha's Vineyard and the central part of Cape Cod were free of ice at a time when the regions to the east and to the west were still covered by the South Channel and Buzzards Bay lobes respectively. Remembering that the coastal shelf was probably considerably higher at that time than it is today, and that the Vineyard, Nantucket and the Cape may well have been continuous dry land, it at once becomes apparent that there was thus opened up an area which soon became available as a refuge for that migration of southern coastal plain species of plants which probably began as soon as the ice commenced to retreat.

It is necessary to point out here that there is a lack of complete agreement as to the exact period of subsidence of the continental shelf and as to whether this migration might have occurred *previous* to the advent of the Wisconsin ice or whether it could not possibly have taken place until after the glacier had receded.

Douglas Johnson, the eminent student of coastal phenomena, in discussing the date of submergence of the Banks cuesta (i. e., the New England-Acadian portion of the outer coastal shelf) states that

"we should expect the subsidence to be at least post-Miocene and more probably post-Pliocene."[1] And further, "It seems probable that the date of submergence of the drowned topography must be post-Tertiary."[2] Johnson, then, is inclined to view the elevation of the continental shelf as pre-glacial rather than post-glacial, a condition which would have necessitated the plant migration having antedated the advent of the Wisconsin ice. And, indeed, Fernald sees no reason why these plants should not have moved northeastward along the exposed shelf before the coming of the Wisconsin glaciation and "have persisted outside the subsequently glaciated area, finally taking possession of their present isolated habitats on the receding of the ice."[3]

In connection with the present study, however, it matters little whether these species of the southern coastal plain reached the New England area before or after the last glaciation. In either case they must have moved inland from off the broad shelf to the eastward to take the places left vacant for them by the recession of the ice, and if we are justified in assuming that it was the Cape Cod Lobe of the glacier which receded first, then we are in a position to understand why so many of these species are to be found upon Nantucket and the "Middle" Cape, and, to a lesser degree, upon the eastern portion of Martha's Vineyard and are so generally lacking from the Elizabeth Islands and inner Cape Cod. Even if the western half of the Vineyard, the Elizabeth Islands and the "Upper" Cape were free from ice at the time when this migration was operative, it seems likely that they offered a type of habitat which was less attractive to these coastal plain plants than the low-lying silicious areas of Nantucket and the "Middle" Cape which they must have reached first and where they today abound, seldom exhibiting a tendency to widen their ranges into the neighboring regions. And although, as Fernald suggests, these plants may have persisted upon the outer shelf while the ice still covered the area inland, it is nevertheless probable that the Nantucket-"Middle" Cape region would have been the first to witness their return.

Conclusion: In summing up, it may be said that, considered from the viewpoint of broad, geographic origins, the native flora of the

[1] Johnson, D. The New England-Acadian Shoreline. New York. 302 (1925).
[2] Ibid. 312, 313.
[3] Fernald, M. L. A Preliminary Statement of Results of Studies on the Northeastward Distribution of the Coastal Plain Flora. Amer. Jour. Sci. 4th Ser. xl. 18 (1915).

Elizabeth Islands is seen to consist of three distinct elements. In the first place, there are those species (less than 20%) which exhibit a relationship with the flora of the southern coastal plain. Their presence upon these islands is to be explained upon the basis of a former land connection with New Jersey and southward which took the form of an elevation of the outer coastal bench, now submerged, and which, either prior to or following the Wisconsin glaciation, permitted of the migration of plants from the southwest to the New England area and even farther north and east. That so many more of these southern plants occur upon Cape Cod and Nantucket than upon the Elizabeth Islands is probably to be explained by the behavior of the glacial lobes which covered this area and which, by their differential recession, seem to have rendered the former areas accessible to occupation by plants at an earlier date. Secondly, there is a small percentage (less than 9%) of plants displaying a boreal affinity, the occurrence of which may be attributed to a counter extension southward along this same uplifted shelf. And the fact that the Elizabeth Islands have received a smaller number of these northern representatives than either Cape Cod or Nantucket is probably to be accounted for on the basis of their inland position and the character of the habitat which they offer, which is, in general, less favorable for these northern plants than the situations which they occupy on the "Lower" Cape. And, finally, there is the overwhelming majority (over 70%) of plants occurring on the Elizabeth Islands which show an essential relationship with the flora of the mainland and which give to the islands the dominating character of a Canadian-Alleghanian region. The prevalence of this continental element is doubtless due to the close geologic and physiographic similarity existing between these islands and the "Upper" Cape. Thus it will be seen that the evidence derived from a study of the geographic origin of the flora of the Elizabeth Islands fits rather well into what is already known concerning the history of the neighboring territory and that these islands take their place botanically as an extension of the adjacent mainland rather than as a link in that chain of outposts of a formerly continuous but now highly disrupted coastal plain flora extending from the South Atlantic States to Newfoundland.

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(*To be continued*)

GENTIANA PROCERA Holm, forma **laevicalyx**, n. f. calycium carinis, glabris.—Locally in Michigan and Indiana. MICHIGAN: shore of Lake Superior, *Whitney;* low wet grounds, Detroit, September 26, 1901, *Farwell*, no. 1447 c. INDIANA: frequent in one place in the sedge border of the north side of Bruce Lake, Fulton County, September 21, 1928, *Deam*, no. 46,341 (TYPE in Gray Herb.).

G. procera Holm, Ott. Nat. xv. 111, 179, t. xii. figs. 3–5 (1901), ordinarily has the keels of the calyx scabrous at least at base. Forma *laevicalyx* appears to be inseparable from it in any character except the quite glabrous calyx; but on account of this character it is likely to be mistaken for the much smaller *G. Victorinii* Fernald, RHODORA, xxv. 87, t. 139 (1923) of the estuary of the St. Lawrence. *G. Victorinii*, however, besides by its much smaller flowers, is distinguished from *G. procera*, forma *laevicalyx* by its shorter and more erect branches and peduncles, much less fringed corolla-lobes and stipitate (instead of essentially sessile) capsule.—M. L. FERNALD, Gray Herbarium.

THE IDENTITY OF ALOPECURUS AEQUALIS.—Following the lead of Schinz & Thellung,[1] progressive botanists have taken up the name *Alopecurus aequalis* Sobol. Fl. Petrop. 16 (1799) in place of the later *A. aristulatus* Michx. Fl. Bor.-Am. i. 43 (1803) or *A. fulvus* Sm. Engl. Bot. xxi. t. 1467 (1805). A discussion of the question was published by me in RHODORA, xxvii. 196 (1925). More recently, however, Jansen & Wachter, in a detailed study of the genus, *Floristische Aanteekeningen XXIV* (*Alopecurus*), attempt to show[2] that the iden-

[1] Schinz & Thellung, Bull. Herb. Boiss. 2me sér. vii. 396 (1907); Viertelj. Naturf. Gesells. Zürich, lxvi. 291 (1921).

[2] Jansen & Wachter, Nederlandsch Kruidkundig Archief, Jaarg. 1929, Afl. i. 69 (1929).

tity of *A. aequalis* is open to question. Their chief point is that, since species no. 44, *Alopecurus geniculatus*, of Sobolewski was really not an *Alopecurus* at all but *Agrostis stolonifera*, with "corollis muticis," we are not fully justified in inferring that Sobolewski's species no. 45, "ALOPECURUS AEQUALIS. Aristis gluma aequalibus (Sob.)" has been correctly identified. Although Jansen & Wachter feel that the identity of *A. aequalis* is uncertain, they admit that the brief diagnosis given of it, "Aristis gluma aequalibus" is a characteristic mark of the species ("Dit is inderdaad een karakteristiek kenmerk der soort"). Sobolewski misidentified plate 564 in Flora Danica as *Alopecurus geniculatus*, whereas it really represents *Agrostis stolonifera* with a tightly contracted panicle. Surely any one else looking casually at the plate, without noting the details, might readily pass it as *Alopecurus*. Its habital resemblance to plate 861, representing *Alopecurus geniculatus*, is striking enough. Consequently, when Sobolewski described a new species as *Alopecurus aequalis*, which differed from his conception (Fl. Dan. t. 564) of *A. geniculatus* by having "Aristis gluma aequalibus" and which "In lacubus natans est," he was giving a rather vivid account of the plant subsequently described as *A. aristulatus* Michx. (1803) and as *A. fulvus* Sm. (1805). Unless some more convincing objection is brought forward we shall be justified in continuing the use of the name *A. aequalis* in this sense. —M. L. Fernald, Gray Herbarium.

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